v. Sextupoles

Sextupole magnets are required in order to compensate for the natural chromaticity of the machine and to correct for the sextupole field generated in the dipoles, by saturation and superconductor magnetization. The sextupoles have an effective length of 0.75 m and are located at each arc quadrupole and at the Q9 quadrupoles in the 3-4, 7-8 and 11-12 o'clock insertions, resulting in a total number of 144 per ring.

The parameters of the sextupole magnets are given in Table 5-1. The sextupoles must be rather strong, capable of $\int B''dl$ = 1150 T/m. This strength makes it desirable to build separate correctors rather than correction coils internal to the dipoles. Because there may be more than the initial two families of these magnets, it is best to design them for a relatively modest current; this reduces the size of the bus work, power supplies and heat leak due to cryogenic feed-throughs. Figure 5-1 shows a cross-section of the sextupole magnet (the cold mass), and Fig. 5-2 shows the pole tip-coil winding configuration in greater detail. The sextupole design uses accurately stamped steel laminations for the yoke and pole tips. The field shape is dominated by the iron, easing the construction tolerances for the coils. The coils are wound from NbTi multifilamentary wire, and the laminated "cold" steel yoke is mounted within a cryostat common to the corrector-quadrupole-sextupole package.

Referring to Fig. 5-1, the sextupole magnet surrounds a cold stainless steel beam tube of standard aperture common to the CQS assembly. The beam tube is welded at one end to a beam position monitor assembly which, in turn, is fastened to the stainless steel end plate of the sextupole yoke; thus, everywhere within the sextupole bore the beam tube fits loosely within the confines of the pole tips. The coils consist of 200 turns of 0.5 mm diameter multifilamentary wire wrapped with 25 μm Kapton insulation with 48% overlay and embedded in a fiberglass/epoxy matrix; they are wound on a machined G-10 form and secured to the pole tips by a scheme employing beryllium copper retainer springs and aluminum locking wedges with intervening G10 insulator strips (Fig. 5-2). The characteristics of the wire are given in Table 2-5.

Table 5-1 . Sextupole Magnet Parameters

No. sextupoles - in arcs	276	
- @ Q9	12	
Magnetic length	0.75	m
∫B″ dl @ 100 A	1150	T/m
∫B (25 mm) dl @ 100 A	0.360	T·m
Maximum operating current	100	A
Quench Current	200	A
Burnout current	250	A
Coil, number of turns	200	
Wire diam., bare	(0.020 in.) 0.5	mm
Coil length, overall	(32.0 in.) 0.81	m
Inductance @ 100A	530	mH
Stored energy @ 100A	2.64	kJ
Yoke, iron length	(31.94 in.) 0.81	m
Yoke, length inc. end plates	(32.25 in.) 0.82	m
Yoke, o.d.	(10.5 in.) 266.7	mm
Yoke, inscribed diam.	(3.070 in.) 78	mm
Lamination thickness	(0.0598 in.) 1.519	mm
Weight of steel	(550 lb) 249	kg
Number of cooling channels	4	
Diameter of cooling channels	(1.187 in.) 30.15	mm
Bus cavity width, height	(1.25 in.) 31.75	mm

The yoke laminations are stamped from 1.5 mm thick low-carbon steel sheet. They have the same external configuration as the quadrupole laminations. Assembly and alignment is as described for the arc quadrupole, with which the sextupole and corrector share a common support structure and helium containment vessel.

The cryostat is the structure which must make the transition from the 4 K environment of the magnet cold mass to ambient temperature; the sextupole, quadrupole, and corrector are mounted in one common cryostat.

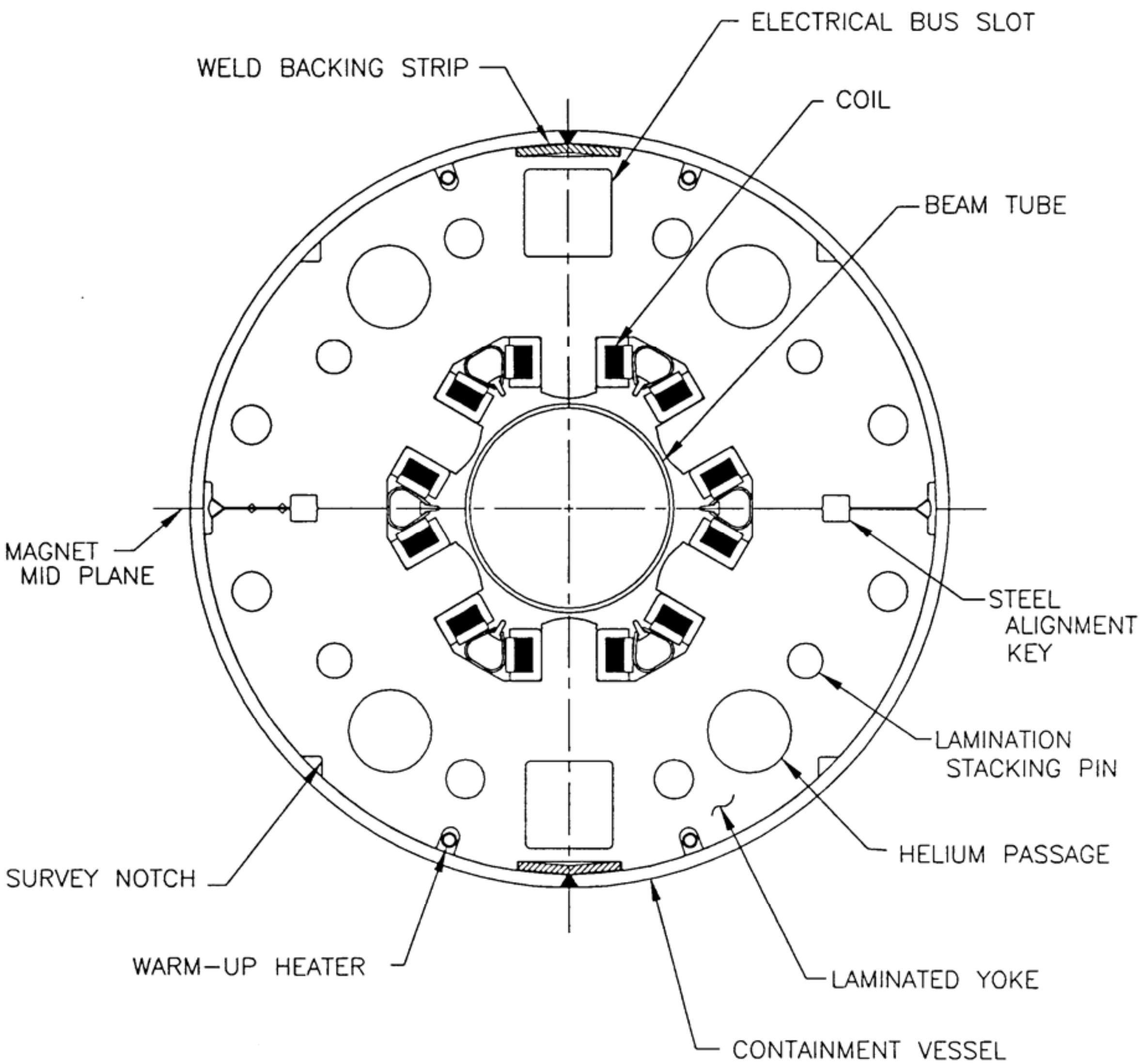

Fig. 5-1. Arc sextupole cross-section (yoke i.d. = 78 mm).

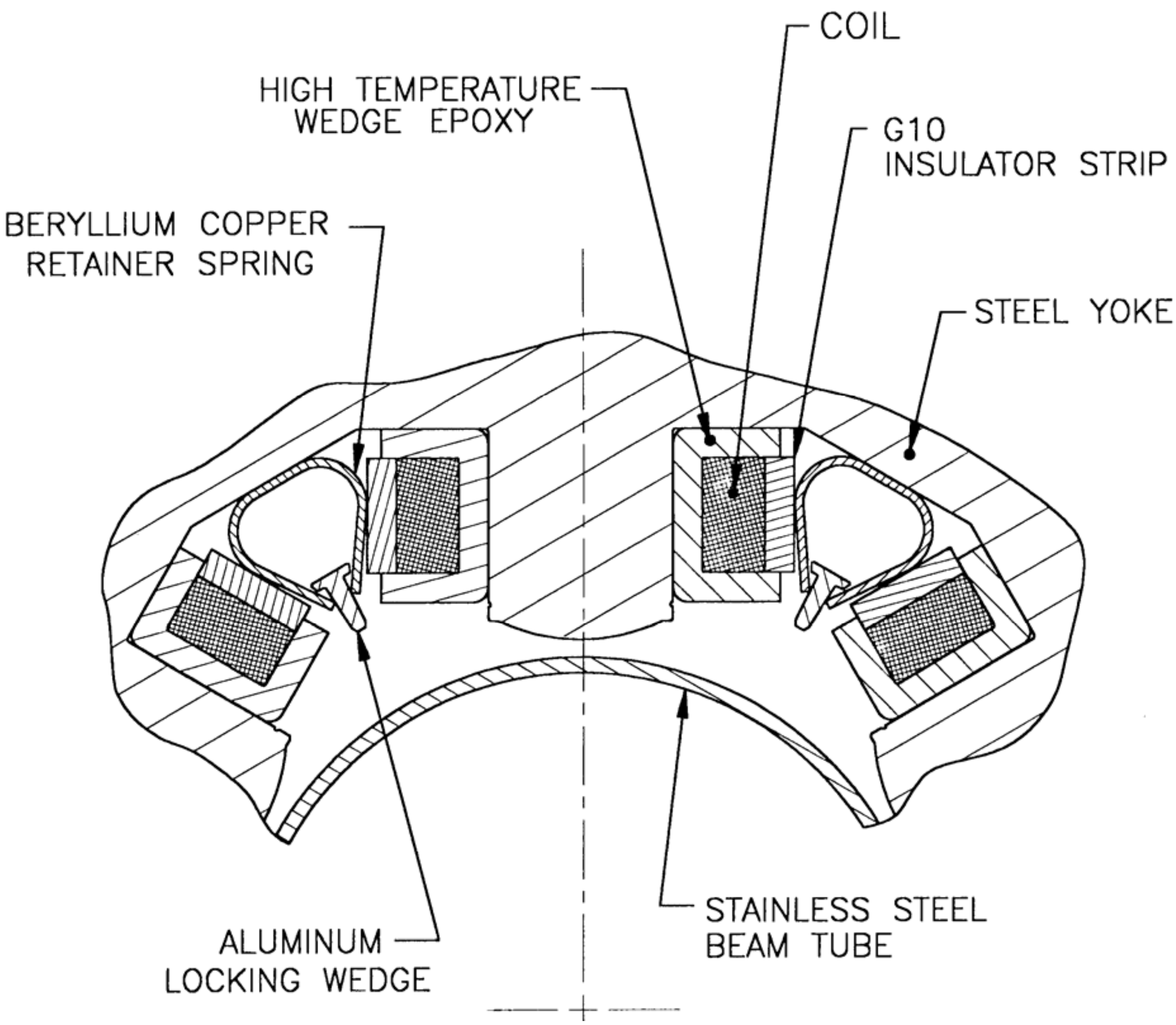

Fig. 5-2. Sextupole details.

The quench performance of sextupoles built as prescribed was excellent, with the magnets usually reaching the limit of the conductor in a few quenches, in both polarities. However, the quench performance of about 30 magnets was poorer, although adequate for operation at currents below 50 A. The cause of the problem was traced to an unauthorized change in production procedures. Fortunately, places were found in the lattice where the operating current was not expected to exceed 50 A. Thus far, no sextupole has quenched in RHIC.

The integral transfer function for a typical sextupole is shown in Fig. 5-3. The saturation of the pole tip is responsible for the decrease of the transfer function at high current and is in agreement with calculation. The large value (~1%) of the first allowed harmonic (Fig. 5-4) is a consequence of the simplicity of the coil construction and is acceptable for these magnets.

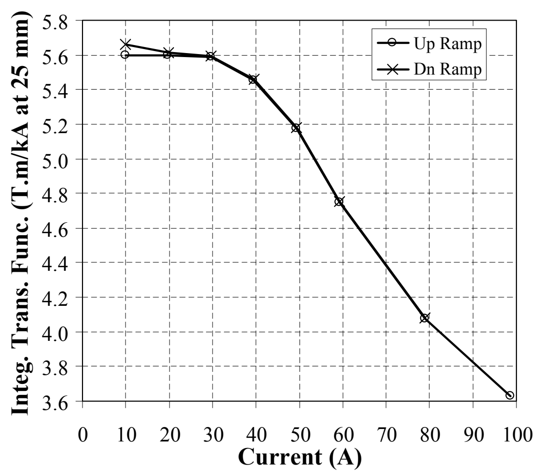

Fig. 5-3. Integral transfer function in SRE211.

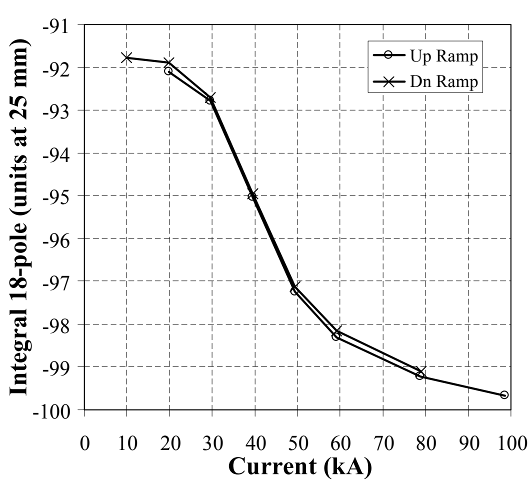

Fig. 5-4. Integral of the first allowed harmonic (b_8) in SRE211.